54938

AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D.C. 20523

REVIEW OF SOIL CHEMISTRY PROJECTS IN THE OFFICE OF THE SCIENCE ADVISOR

September 1987

OUTLINE

I. INTRODUCTION

II. PROGRAM OBJECTIVES

III. DISCUSSION

Soil Chemistry

Program Overview

IV. RECOMMENDATIONS

V. PROJECT PROFILES

Dr. Anson Bertrand
Consultant
Office of the Science Advisor
Agency for International Development
Washington, D.C. 20523

The PSTC-CDR Soil Chemistry Program

I. INTRODUCTION

This review of the A.I.D. Science Advisor's program in Soil Chemistry consisted of examining the files for those Soil Chemistry projects which have been approved for funding by the A.I.D. Program in Science and Technology Cooperation (PSTC) and the U.S.-Israel Cooperative Development Research (CDR) Program. Included are projects which have been concluded and others which have just been approved for funding and little work has been accomplished. The files are not complete for several projects. Some progress and final reports are not present. The comments in this review are based on the information available in the files and should not be taken as the final word on the progress of or worth of the individual project or the program as a whole.

II. PROGRAM OBJECTIVES

It is assumed that the PSTC and CDR Soil Chemistry program is intended to:

1. Support state-of-the-art soil chemistry research that promotes innovation and adds the basic store of knowledge.

2. Support soil chemistry research that is needed for improvement of agriculture in developing countries.

3. Support soil chemistry research that is conducted cooperatively between developing country scientists and scientists in the U.S.*

4. Support soil chemistry research that will enhance the scientific capability of the developing country and is useful to the U.S.

III. DISCUSSION

Using the above assumptions the reviewer examined the project files and prepared a brief analysis of each project (attached). It was assumed that each project in the PSTC and CDR programs must stand on its own merits and that the collection of projects in soil chemistry need not add to a comprehensive program in soil chemistry. It should address important problems for developing countries. The following is a brief statement of the field of soil chemistry. Some research areas that especially need persuing for agriculture in developing countries are identified.

---

* Editor's note: While the Program in Science and Technology Cooperation encourages U.S.-developing country scientific cooperation, this is not a necessary ingredient of projects submitted by fully experienced developing country scientists.

Soil Chemistry

Broadly speaking, Soil Chemistry may be defined as the study of a wide variety of soil chemical processes and the chemical composition of soil constituents.

Modern soil chemistry research requires the use of advanced technology including IR, ESR, NMR, SEM, computer technology, and models to solve complex problems and add to our knowledge.

Past studies of crystalline soil materials were facilitated by removal of amorphous soil materials. Recent studies of these amorphous soil materials using modern technology have revealed much of their importance to surface reactions, anion and cation exchange, and soil acidity. However much remains to be learned about the nature of the amorphous materials and their roles in specific soils. Adsorbed water reacts with both the solid particle surfaces and the ions held on these surfaces. Water is more strongly bonded to some surfaces than to others. The role of Hydrous oxides in bonding water is only partially understood for many soils. The identification of interstratified clay minerals needs additional work to fully understand chemical behavior of many soils.

Although solid phase equilibria and the nature of complexes in the soil solution between cations and colloidal organic matter have been elucidated, much remains to be done to completely understand the nature of chemical reactions between specific organic materials (acids) and other constituents in the soil. This is especially important with respect to effects of organic acids on solubility of other compounds and the availability of plant nutrients.

Progress has been made in establishing redox potentials for many of the possible oxidation-reduction reactions that may occur in soil, but much remains to be done to establish reproducible, meaningful, field measurements of redox potentials. Many additional studies are needed to fully understand the relationships between redox potentials and plant responses.

Our understanding of surface adsorption phenomena, mechanisms of bonding inorganic anions, organic molecules, and cations to soil particle surfaces has increased greatly in recent years. Modeling of adsorption reactions through the use of adsorption equations has led to practical applications of soil chemistry to environmental quality problems.

The chemistry of fertilizer nutrients, including placement in the soil, upon fertilizer reactions in soils is reasonably well understood in temperate region soils, but much additional work is needed in some tropical soils.

Micronutrient and trace metal chemistry in soils has been studied from the standpoint of crop production. There is increasing interest in the chemistry of heavy metals in soils and soil amendments from the standpoint of environmental pollution.

Soil Chemistry, Soil Fertility and Plant Nutrition are closely associated, both in the research laboratory and in practical field research. Many studies have dealt with soil fertility evaluation, N,P,K, and trace mineral fertilization and reactions in the soil, but much remains to be done to fully understand specific reactions and to be able to prescribe fertilization practices that will result in optimum utilization of fertilizers. Many future studies will place emphasis on reactions taking place in the soil solution-rhizosphere interface as researchers in soil fertility strive to increase efficient use of nutrients and also increase yields.

Future soil chemistry research will build on the knowledge that has been acquired about the nature of chemical reactions and the chemical compositions of soils. Through application of modern technology we will expand our knowledge of soil chemistry and our ability to apply that knowledge to specific problems in specific soils throughout the world.

All of the above mentioned areas of Soils Chemistry present interesting and researchable problems. From the standpoint of the SCI program, in support of development, the following merit special attention.

1. The study of soil chemical properties that affect water availability.

2. Studies to better understand the nature of chemical reactions between organic materials and other constituents in the soil.

3. Studies to more fully understand the relationships between oxodation-reduction reactions in the soil and plant responses.

4. Studies to better understand adsorption and desorption phenomena in soil as related to availability of plant nutrients.

5. Studies to better understand the chemistry and behavior of mineral elements of the soil that are both required for plant growth and are antagonistic to plant life.

6. Studies to improve the ability of crop plants to utilize native plant nutrients, i.e., P in soils that have high A. and Fe.

7. Studies of soil chemical properties that affect the physical characteristics of soils, especially those that accelerate erosion or leaching.

8. Studies of soil chemical processes that have potential to adversely affect the environment.

Program Overview

The soil chemistry projects reviewed address three broad areas:

1. Redox chemistry of lowland soils

2. Soil salinity control and plant production

3. Soil amendments to enhance availability of nutrients

Project files examined in this review included the following:

1. (2.A22) Redox Chemistry of Acid Sulfate Soils of Thailand

2. (3.F10) Redox Chemistry and Fertility problems in the Wetlands of the Transmigration Areas of Sumatra

3. (3.A02) Soil Salinity Control for Growth of Plants which can Serve as Energy Sources.

4. (C5-001) Field Application of New Theories on Facilitation of Saline Water Irrigation by KNO^3

5. (C5-325) Commercial Crops Under High Saline Conditions Using Advanced Sand Culture Methods.

6. (5.249) Development of Appropriate Technology for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils

7. (3.F49) Vicariant Fertilization of Tropical Soils

8. (7.136) Nitrogen Dynamics of Acacia Senegal Agroforestry Systems in Sudan.

Each of these projects have worthy objectives that will contribute to overall scientific knowledge that will be useful to developing countries. These projects differ considerably in their ability to establish lasting linkages and to provide for strengthening the scientific capability of both a developed and a developing country. (See comments on each project.)

For the most part, these projects are applying known theory and technology to address problem in developing countries rather than adding to the basic store of soil chemistry theory and practice. It is the opinion of this reviewer that the SCI Soil Chemistry Program should be striving to support more projects that have potential to promote innovation and add to the basic store of knowledge.

The projects concerning redox potential have potential to contribute useful information concerning solubility, ion activity,

soil weathering and plant nutrition in acid sulfate soils. These soils will become more important as population pressure forces more and more people to depend on them. Although it is important to aim research at developing management systems for acid sulfate soils, it is the opinion of this reviewer, that more of the effort in these projects should be directed at developing a more complete understanding of the physio-chemical dynamics of these systems. This is needed in order to develop predictability. More effort to model these systems would seem to be desirable.

The PSTC projects concerning redox potentials of soils constitute the entire A.I.D. program in this area of science. It is complementary to the work of several of the IARCs and is not duplicative of the work of others. It serves as a valuable vehicle for cooperative research of interest and importance to developed and developing countries. Further studies to relate redox potentials to crop growth and to increase prediction ability would seem to be warranted.

The projects concerning use of saline water are addressing important problems which are present in millions of hectares of potentially useful land throughout the world. Solutions will facilitate food production and enhance development. It is the opinion of this reviewer that these projects are somewhat deficient in attention to plant physiological concerns and detailed studies of the interactions between water quality and nutrient balance and supply. More effort to develop a better understanding of the nature of the chemical reactions taking place is recommended.

Although salinity is the central theme in each of these projects, there is no significant overlapping. They address specific problems in specific countries and do not duplicate the work of others. Technology being used is that which is available in the developed world.

The three projects that are directed at enhancing the availability of plant nutrients may be thought of as contributing to the technology of providing the raw materials for plant growth. The acquisition of fertilizer is a serious problem for developing countries which must use scarce foreign exchange to purchase and import fertilizer, especially N and P carriers. Two of the projects are designed to try to enhance the availability of native P in the soil. The other addresses N-fixation by a woody legume. Both activities are highly laudable and needed.

The project on vicariant fertilization is an effort to apply known relations between Si and P in the soil. It is not intended to provide new basic information, but the information gained will be useful in developing countries that have similar highly weathered soils. This project will also contribute useful knowledge if it is able to develop a cheap source of Si for soil amendments. This

project will not materially add to the basic knowledge of soil chemistry, but it will provide a vehicle for cooperative work between scientists in Delaware and Panama.

Understanding the relationships between soil organic matter, freshly added plant material, and the role of woody legumes in soil management systems of the Sahel is needed. The project on nitrogen dynamics of A. senegal has the potential to add useful information for developing countries such as Sudan where expansive areas of arid and semi-arid land must be used for food and fuel production. This project is well designed and if executed according to plan should contribute information that will be widely applicable. It will not add significantly to the store of basic soil chemistry knowledge.

The comments above indicate that each project has or will contribute useful information. They do not constitute a comprehensive program in Soil Chemistry aimed at producing fundamental information needed to advance the field of Soil Chemistry. However, they do constitute a collection of activities that involve developed and developing country scientists in collaborative research on problems that are important to the developing country concerned. The discussion of Soil Chemistry, in a preceding section, identifies many interesting and important problems that could be researched. The soil chemistry problems being addressed by the PSTC and CDR programs are important and have potential to contribute to developing country food production. Future programs should continue to emphasize those activities that have potential to contribute to the raw materials required for plant growth--plant nutrients.

IV. RECOMMENDATIONS

Because the files for these projects are incomplete and because some projects have terminated and others are just beginning, it is difficult to evaluate these Soil Chemistry projects as a program. Therefore, each project was evaluated separately, on the basis of documentation on the file. Based on this limited analysis of the activities in Soil Chemistry being supported by PSTC and CDR the following recommendations are made that:

1. Efforts be made to develop an overall Soil Chemistry program statement to guide selection of future projects in this area. Such a program statement should be designed to complement other soil chemistry activities being supported elsewhere by A.I.D. and others. It should emphasize state-of-the-art technology and address problems that have potential to add to the basic store of knowledge in chemistry theory and practice and also add significantly to improved food production capability of developing countries while maintaining the natural resource.

2. Future projects be selected within the overall program recommended above, that are compatable to development of networks of developing country scientists. The fostering of research networks which include both developed and developing country scientists should be an objective of this program.

3. Procedures be developed and implemented to insure that grant holders submit interim and final project reports on time and that project holders report all Scientific Publications based on the project results.

Project Profile

Project No: 2.A22

Project Title: Redox Chemistry of Acid Sulfate Soils of Thailand

Project Duration: July 1, 1982 - June 30, 1985

Funding Level: $179,784

Grant Holder: Louisiana State University - Laboratory for Wetland Soils and Sediments - Center for Wetland Resources

Principal Investigator: William H. Patrick, Jr.

Cooperating Institutions:

Department of Agriculture of Thailand
Department of Land Development of Thailand
Soils Department, Kasetsart University, Thailand

Project Purpose:

To study changes that occur in acid sulfate soils of South East Asia when they are drained by developing information on the interrelations among soil aeration, redox potential, pH, and salinity in controlling the concentration and activities of metal ions Fe^{2+}, Mn^{2+}, Al^{3+} that are largely responsible for plant toxicity in these soils.

Specific Objectives:

(1) To evaluate in detail the redox and Ph chemistry of a range of acid sulfate soils from Thailand.

(2) To set up in the laboratory a range of redox, Ph and salinity conditions that occur in acid sulfate soils under natural conditions and determine the response of plants to these conditions.

(3) To train Thai students in recently developed methods used in studying redox and Ph chemistry of wetland soil.

Results: (scientific)

A Thai graduate student working in the laboratory at LSU found that, "the growth of rice was affected by both redox potential and pH, with dry matter increasing with increasing pH and highest under moderately reduced (EH = +250 mV) conditions." Redox and pH were also found to affect iron availability, whereas manganese availability was governed solely by redox potential and aluminum

solely by pH. Tolerant rice varieties had lower concentrations of iron and aluminum and higher concentrations of phosphorus than the sensitive varieties.

Another Thai graduate student working at LSU found that when three acid sulfate soils from Thailand were flooded the absence of oxygen led to an increase in pH and water soluble iron and manganese, whereas EH and aluminum concentrations were found to decrease under anaerobic conditions. Increasing levels of organic matter enhance the effects of reductions. Reduction was found to be retarded in extremely acid soils.

In another experiment this graduate student found that the relationships between available iron and manganese as a function of EH were different when soils were taken from reduced to oxidized conditions as compared to that found when oxidized soils were reduced, forming a hysteresis pattern.

Another series of laboratory experiments on acid sulfate soils from Thailand indicated that mineralization was highest under intermediately reduced conditions. This work has been reported in "The Soil Science Society of America Journal" Vol. 51, pp. 630-634. Other American and Thai graduate students have further elucidated the relationships between redox potential and pH on mineral ion content of the soil solution.

A U.S. graduate student working in Thailand, following leads from the Laboratory, found that in the field goethite (FeOOH) was the solid phase of iron controlling the oxidation-reduction process in these soils. Iron was found to play an important role in governing the availability of trace metals in these soils. Water soluble iron was found to be highly correlated with water soluble As, B, Cd, Cr, Mn, No, Ni, and Pb.

Although extremely low pH's and elevated levels of water soluble and exchangeable iron and manganese were found in many soils, mortality of rice was found only in soils with high levels of aluminum. Water soluble and exchangeable aluminum were inversely related to pH. Dry matter production and pH were found to be positively correlated.

Other field and laboratory studies are continuing. The project participants expect to publish at least ten journal articles from this work.

Results:

This project formed a bond between the scientists and administrators of the Department of Agriculture, the Department of Land Development, the Soils department of Kasetsart University in Thailand and the Laboratory for Wetland Soils and Sediments at LSU. Five Thai students received training in modern experimental

methods in wetland soil chemistry at LSU. Two visiting scientists from Thailand completed PhD's at LSU. A fully equipped laboratory for soil chemistry research was developed in Thailand and one U.S. graduate student completed one year of field research in Thailand. Collaborative research between scientists in Thailand and scientists at LSU is continuing long after the termination of this project.

Improved Scientific Capacity: (developing country)

This project appears to have resulted in an increased capacity for research in the chemistry of wetland soils and especially in how to study and design management programs for acid sulfate soils of Thailand. The students and scientists who worked in the laboratory at LSU learning the most modern research methods, will undoubtedly be more able to effectively conduct research in soil chemistry as a result of the collaboration that ocurred during this project. The knowledge of modern techniques and personally knowing scientists in the U.S. who are working in the same field will be of lasting benefit to the Thai scientists. The laboratory that was built and equipped in Thailand for soil chemistry work will serve current and future students and provide a base for future soil chemistry research work in Thailand.

Improved Scientific Capacity: (U.S.)

The opportunity to interact with students and scientists from Thailand and to be able to work on acid sulfate soils from Thailand will have a lasting affect on the nature and quality of teaching and research that is done in the laboratory for Wetland soils at LSU. Students and scientists who have had an opportunity to study in Thailand and to exchange information and ideas with colleagues in Thailand will be more effective teachers and researchers in the future.

Discussion:

Relation to A.I.D. Programs:

Because acid sulfate soils occupy large areas of many developing countries, it is important that means be found whereby these soils can be used effectively for food production. This project contributes to A.I.D.'s objective of trying to help developing countries become self-sufficient in food.

This project is not duplicative of other A.I.D. supported projects, but it is complementary to S&T/AGR's efforts to develop effective soil management practices for developing countries.

Relation to SCI activities:

This project contributes to SCI's efforts to develop knowledge required for effective use of acid sulfate soils. It is complementary to project 3.F10 and is not duplicative of other SCI sponsored activities.

Relation to state-of-the-art and the work of others:

The background documentation given in the project proposal was quite complete when it was prepared in 1982. It indicates clearly that this work used state-of-the-art methods and did not duplicate the work of others. It provided information which has been useful to others in more recent studies of acid sulfate soils.

Project Profile

Project No: 3.F10

Project Title: Redox Chemistry and Fertility Problem in the Wetland Soils of the Transmigration Areas of Sumatra

Project Duration: August 15, 1983 - July 15, 1986

Funding Level: $280,049

Grant Holder: Sukarami Research Institute for Food Crops, Indonesia

Principal Investigator:

Co-Investigators:

William H. Patrick, Robert P. Gambrell, Laboratory of Wetland Soils and Sediments, LSU

A. Syarifuddin K, Director, and Arron Jugsujinda, Soil Chemist, Sukarami Research Institute for Food Crops, Pandang, West Sumatra, Indonesia

D.A. Muljadi, Director, and M. Sudjadi, Soil Scientist, Center for Soils Research, Bogar, Indonesia

Cooperating Institutions:

Sukarami Research Institute for Food Crops, Indonesia
Center Soils Research, Bogar, Indonesia
Laboratory for Wetland Soils and Sediments, Louisiana State University

Project Purpose:

To study the redox chemistry and soil fertility and toxicity problems that exist in wetland soils of the Sitiung Transmigration areas and the peat soils in the tidal swamps of Eastern Sumatra.

Specific Objectives:

(1) To conduct collaborative research between the Laboratory for Wetland Soils and Sediments, SARIF, CSR, and TropSoils, to study the redox chemistry processes that influence the availability and toxicity of inorganic soil constituents in the two soil areas.

(2) To train Indonesian graduate students in wetland soil science.

(3) To permit Indonesian soil scientists to learn modern research techniques for wetland soil research.

Results: (scientific)

Soil condition associated with an oranging disease which occurs in flood rice (Oryza sativa) grown on the newly opened area of Sumatra were studied by measuring changes in pH, Eh, Fe and Mn levels in soil solution after flooding and the chemical compositions in the rice plants. It was found that soil pH increased gradually as soil Eh decreased sharply within a week after flooding. Build up of Fe and Mn in the soil solution was very high after flooding. The concentration of Fe in the leaf tissue was slightly higher than the the critical level for Mn toxicity. The disease appears to be due partly to direct Fe toxicity. But the rice plants may suffer indirect Fe-toxicity, i.e., an Fe-induced deficiency of other macro-elements necessary for normal growth of rice plants in some of these soils.

Another study was carried out to investigate the effect of flooding on the release of water-soluble and extractable forms of elements in soils, and also to establish relationship of nutrients with their counterparts in the leaf tissues. Forty-five soils and an equal number of rice leaf samples were collected randomly from the Sitiung Transmigration Area of Sumatra, Indonesia. The results indicated that the solubility and distribution of nutrient elements in the soils were markedly affected by flooding. Flooding caused dramatic changes in oxidation-reduction potential (Eh), pH, and the release of water-soluble and extractable forms of nutrient elements. Further, the Eh of the soils sharply decreased and went down to an average value of -217 mV after 60 days of flooding. Soil pH increased from an average of 5.2 to 6.6. After flooding, average concentration of extractable Fe, Mn, Al, Cu, Zn, Ca, Mg, P, K, and Si was higher than average water-soluble form. Water-soluble and extractable forms of Mn were significantly correlated with soil pH but inversely correlated with soil Eh. The extractable Fe was significantly correlated with soil pH.

Leaf tissue analysis indicated that the rice plants suffered Fe and Al toxicity as their contents were more than 300 ppm; a critical level for their toxicity. The rice plants also suffered deficiency of Ca, P, K, Mg, and Si in the ascending order as their contents were below the critical content for deficiency. P was inversely correlated with extractable Al. Mg was significantly correlated with water-soluble Ca and extractable forms of Ca and Mn. K was inversely correlated with water-soluble form of P. Si was significantly correlated with water-soluble P, Fe, Ca, Mg, P and Cu and extractable Ca. Some nutrients showed either toxicity or deficiency levels in the rice leaf tissues. Fe and Al

toxicities were probably the major cause of oranging symptoms. Other factors which might be responsible for yield depression were the deficiencies of Ca, P, K, Mg, and Si caused by low soil Eh thereby resulting in their precipitation with amorphous Fe oxyhydroxides (Fe(OH)3).

Results: (linkages)

This project is designed to require close collaboration between scientists in the U.S. and scientists in Indonesia. There have been visits to each country and frequent communications between the persons involved in each country. The sharing of experiences, technology and concerns will undoubtedly establish lasting collaboration between the persons involved.

Results: (improving scientific capacity)

Developing country:

The scientific capacity of Indonesian scientists to study the chemistry of wet soils will be enhanced by this activity. They will learn new techniques and will be able to design and conduct similar experiments in other areas after this study is completed.

U.S.:

The benefit of this project to U.S. science will be the experiences and data gained by U.S. scientists as they work in a tropical environment.

Discussion:

Relation to other A.I.D. projects:

This project complements the other PSTC project concerning redox potential in soils. It is also complementary to work that is underway in several IARCs where rice is the study crop. This project will also contribute knowledge that will be valuable to IBSNAT, SMSS, and the Soils CRSP and will address an important problem in management of tropical soils.

Relation to other PSTC projects:

This project is not duplicative of any ongoing S&T or PSTC projects. It is complementary to several activities.

Relation to state-of-the-art and the work of others:

It is well documented that redox potential and pH are the principal factors influencing the mobilization and immobilization of nutrient elements in flooded soils and their availability to rice plants. It is, therefore, important to differentiate the

extent of problem caused either by redox potential and pH induced toxicity or nutrient deficiencies which may be aggravated by toxic soil conditions.

This project utilizes state-of-the-art technology to address important questions concerning use of large tracts of land in the tropics. It is not duplicative of other work and will complement similar studies by other scientists elsewhere. This and subsequent work relating to soil toxicities caused by reducing conditions will eventually provide data sufficient for modeling and thereby reduce the need for many specific studies to develop solutions to problems in lowland soils. Prediction ability will be enhanced by this project.

Project Profile

Project No.: 3.A02

Project Title: Soil Salinity Control for Growth of Plants Which Can Serve as Energy Source

Project Duration: June 1983 - October 1986

Funding Level: $150,000

Grant Holder: King Mongkut's Institute of Technology, Bangkok, Thailand.

Principal Investigator: Benjamas Chatong M.S. (Soils)

Co-Investigators: Bandit Fungtammasarn Ph.D (MEEng)

Cooperating Institutions:

Division of Engineering, Land Development Department, Ministry of Agriculture and Cooperatives, Thailand.

Department of Agronomy and Soils, Washington State University.

Project Purpose:

To increase use of saline soils and to increase production of non-edible oil in Thailand.

Specific Objectives:

(1) To develop a proper soil salinity control system for planting a non-edible oil producing crop.

(2) To develop a suitable wind powered water supply.

(3) To carry out experiments on the planting of Jatropha carcas (Linn) so that a method to produce optomum yields with maximum oil content may be developed.

(4) To investigate the characteristics of extracted oil as a combustable fuel source for powering diesel engines used in small fishing boats.

Results: (scientific)

A series of experiments both in the laboratory and in the field were conducted in Thailand. Early experiments relating to soil

salinity control were conducted using potted soil treated with various combinations of rice hulls and gypsum prior to leaching. Results indicate that leaching of salts was enhanced by addition of organic matter and gypsum.

The leaching study was followed by an experiment in which plants were grown in the pots of soil that had been leached. No definite results are reported.

Subsequent experiments were conducted to determine the relative efficiency of soil salinity control methods by leaching and leaching with addition of 3% rice husk + 6% gypsum. Plant growth was also observed. These field experiments which compared leaching with leaching + rice husks + gypsum produced the following results:

(1) Addition of rice husks and gypsum enhanced infiltration.
(2) Addition of rice husks and gypsum decreased salinity more than leaching alone.
(3) Plants grown with leaching alone had better growth than with any other treatment.

Another experiment attempted to identify the causative agent in the death of Physic-nut-trees in saline soils. The types of microorganisms present in the soil were identified without finding any evidence of pathogenic organisms in the soil.

Efforts to develop a wind powered source of water for leaching saline soils included detailed studies of wind profiles and velocities over time. Extensive data were collected and various correlations are reported. A wind powered turbine was constructed and used to pump water at one location. The wind data collected should be of value in future development of wind driven energy sources in Thailand.

Results: (linkages)

Collaboration between scientists in Thailand and scientists at Washington State University's Colleges of Agriculture and Engineering has resulted in linkages that should be lasting.

Results: (Improved scientific capacity)

Developing Country: Experiments conducted in the laboratory and the field with the cooperation of scientists from Washington State University using modern techniques gave developing country scientists an opportunity to use the most modern techniques and to equip a laboratory for future use.

U.S.

Involvement of U.S. scientists in this cooperative study gave them an opportunity to become familiar with salinity problems in a developing country and to help develop ways to overcome salinity problems in soils.

Discussion:

Relation to other A.I.D. projects: Saline soils are extensive throughout the world and they are needed for food production. Salinity is a problem in all A.I.D. sponsored irrigation projects and it is a problem in many non-irrigated project efforts. Development of means to control salinity and use the soil for productive purposes is an aim of many A.I.D. sponsored activities. Although it is not the primary aim of most of them

This project was complementary to S&T/Agriculture's efforts to improve irrigation and soil management. It was complementary to S&T/Energy's efforts to develop low cost energy sources in developing countries.

Relation to state-of-the-art and the work of others: It had been demonstrated long before this project that saline soils could usually be effectively leached if sufficient quantities of high quality water is supplied. What was not known was how much leaching was required for growth of Jatropha carcas (Linn) and if wind power could be used to lift water of sufficient quantity and quality to effect the leaching required. It was also not known if the oil produced would be of suitable quality to power diesel engines for fishing boats. This study used well known techniques to study the factors above. It did not duplicate the work of others.

Project Profile

Project No.: C5-001

Project Title: Field Application of New Theories on the Facilitation of Saline Water Irrigation by KNO^3.

Project Duration: March 1985 - April 1987

Funding Level: $150,000

Grant Holder: Ben-Gurion University of the Negev, Beer Sheba, Israel.

Principal Investigator: S. Herman Lips, Ben-Gurion Univ.

Co-Investigators:

Jiftah Ben Asher, Ben-Gurion Univ.
Enrique P. Pacardo, Univ. of the Philippines.

Cooperating Institutions:

Blaustein Institute for Desert Research
Ben-Gurion University, Israel

University of the Philippines, Los Banos

Project Purpose:

To develop effective methods and techniques for supplementing fresh water supplies with saline water while still maintaining acceptable crop yields.

Specific Objectives:

(1) Increased total yield of selected crops while utilizing waters of various salinities at different fertilization regeimes.

(2) Study the environmental effects (mainly nutritional) on salt tolerance of a given plant species.

Results: (scientific)

None to date.

The research plan is designed to test the hypothesis that salt tolerance of a given plant species is a function of environmental (climate and nutritional) conditions as well, but not only, to its inherent genetic characteristics. Preliminary work has indicated

that salt sensitive plants can be made more tolerant by proper fertilization. This project is designed to determine nutrient uptake by plants subjected to different environments of saline water and fertilization. Field experiments will be conducted in Israel using peanuts and in the Philippines using rice as the test crop.

Results: (linkages)

The co-investigator from the Philippines has worked with the principal investigator in Israel and is familiar with the hypothesis and study techniques. Facilitating similar studies in the Philippines will solidify linkages that should be lasting.

Discussion:

Relation to other SCI Projects: This project is one of the projects sponsored by the U.S.-Israel Cooperative Research Activity (CDR). It is a good example of the intent of this program which is to link scientists in Israel with scientist in developing countries to facilitate exchange of knowledge and to conduct important research of value to the developing country.

The importance of the approach taken in this project in relation to current agricultural practices is the implication that significant yields may be obtained even with salt-sensitive plant species whose tolerance can be enhanced by improved fertilization management. In the long run, the development of salt-tolerant varieties will remain important but, in the short run, a simpler alternative approach such as the one used in this project may be more effective and has potential for immediate utilization of saline water for food production. This difference is especially important in developing countries where the population increase is fast and agriculture cannot keep pace with increasing food demands.

Relation to other A.I.D. programs: Increasing the ability of LDCs to produce their own food is one of the primary goals of A.I.D.'s programs. The use of indigneous resources such as saline water and local plant varieties to increase yields is a worthy goal and is in complete harmony with the objectives of A.I.D.

A.I.D. is sponsoring extensive irrigation projects throughout the developing world. This project will be complementary to these efforts. It is also complementary to the projects that concern fertilization of crops in developing countries.

Relation to state-of-the-art and work of others: The main obstacle to the useage of saline water is the sensitivity of plant species to salt. Salt sensitivity may be overcome by breeding salt-tolerant varieties or by developing agrotechniques that permit the use of standard varieties with saline water.

Traditional definitions of irrigation water quality are aimed at management of irrigation for salt control in the soil. In other cases the definition of salinity is more oriented towards plant productivity. Optimum nutrient conditions for the plants is usually assumed, this is not the case in the field. This project is innovative in that it proposes to use KNO^3 in conjunction with saline water to increase the resistance and adaptability, of known high-producing species, to salt. If successful, this approach will serve as a basis for development of new saline water agrotechniques and will provide essential guidelines for plant breeding and the creation of new plant varieties better suited for high productivity under saline conditions.

Project Profile

Project No.: C5-325

Project Title: Commercial Crops under High Saline Conditions Using Advanced Sand Culture Methods

Project Duration: August 1985 - July 1987

Funding Level: $159,000

Grant Holder: Jerusalem College of Technology, Jerusalem, Israel

Principal Investigator: Meier Schwartz, Israel

Co-Investigators: Felix Quevedo, Peru

Cooperating Institutions:

Jerusalem College of Technology
Universidad Nacional Agraria, Lima, Peru

Project Purpose: To develop methods for growing agricultural plants in sand cultures using saline water

Specific Objectives:

(1) To increased the understanding of the physiological and nutritional basis for salt tolerance,

(2) To facilitate selection of crops suitable for production under high saline conditions,

(3) Supply important parameters as tools for creating new salt-tolerant cultivars.

(4) Develop information concerning management of controllable environmental parameters,

(5) Evaluate the possibility of extending crop longevity and vitality under saline conditions,

(6) To design, construct and successfully operate a pilot plant for plant production using saline water in a developing country.

Results (scientific): None to date

Research Plan (in brief):

This project is part of the U.S.-Israel CDR Program. Knowledge recently obtained in Israel from laboratory plant growth experiments for carbon (energy) balance and ionic balance under medium and high saline conditions will be applied to field studies in gravel and water cultures and on sand dunes to produce agricultural crops in a developing country.

Pre-pilot plant experiments will be conducted in Peru during the first year. After the pilot plant is constructed experiments will be conducted to perfect methods for producing plants using saline water. Various ion ratios and various levels of salinity in the water will be tested to verify laboratory results under field conditions. The economic feasibility of field production will be determined.

Results (linkages):

The project plan requires close collaboration between the Principal Investigator in Israel and the Co-Investigator in Peru. Since procedures and pilot plant design will be developed in Israel and implemented in Peru, there will be close collaboration between the cooperators. Such close working relationships for two years should establish lasting linkages.

Discussion:

Relation to other SCI projects: Project C5-001 has similar objectives. Although the objectives are similar, they are not duplicative because project C5-325 is aimed at more immediately applicable technology.

Project Profile

Project No.: 5.249

Project Title: Development of Appropriate Technology for Overcoming Different Mechanisms of Phosphorus Retention in Central American Soils

Project Duration: November 1, 1985 - June 1, 1987

Grant Holder: CATIE, Turrialba Costa Rica

Principal Investigator: Donald L. Kass, Soil Management Specialist, CATIE

Co-Investigators:

Alfredo Alvarado H., Professor of Soils
University of Costa Rica

Roberto Diaz-Romeu, Soil Scientist, CATIE

Julio Henao, Statistician, IFDC

Cooperating Institutions:

The University of Costa Rica
CATIE
IFDC

Project Purpose:

To reduce the cost of phosphorus fertilization in Central America by finding more efficient means of phosphorus application.

Specific Objectives:

(1) To separate the soils of Central America with regard to mechanisms of phosphorus retention.

(2) To test different methods of supplying phosphorus to crops according to the nature and amount of phosphorus retention characteristics of the soils.

(3) Finding the most economical method of supplying phosphorus to crops.

Results: (scientific)

Although the project funding terminated on June 1, 1987, the work plan continues through 1987 and into 1988. Therefore, only an interim report of results is available for review at this time. Thirty seven (37) soils from four Central American Countries were sampled and samples sent to the USDA Soils Lab. at Lincoln, NE for characterization and determination of phosphorus retention. A greenhouse experiment was conducted by a M.S. student using four bean varieties with a range of tolerance to low phosphorus. The student used three soils also with a range of phosphorus retention characteristics. Liming and P application gave a significant positive effective bean yield. Inhibition of P by soaking the seed in a solution of K^2HPO^4 did not increase bean yields except with liming or addition of P to the soil. There were strong interactions between bean variety, P added to the soil, liming and soil type.

Correlations between several soil characteristics and retention of P were established by the USDA Laboratory. This information will be of value to SMSS and other soils projects sponsored by A.I.D.

A second student has begun works on a study to determine the behavior of several important bean varieties from Panama to various soil treatments with regard to P availability. No results are available.

Other field experiments throughout Latin America are planned for late 1987.

Results: (linkages)

The working relationships established in this project involving persons for CATIE, IFDC, the University of Costa Rica and USDA will establish valuable personal and institutional linkages that should exist for a long time. Involvement of student will also enhance the continuation of linkages established.

Results: (Improvement of scientific capacity)

Developing country: CATIE and Central American countries will benefit through increased knowledge of fertilizer requirements of most of the important soils used for bean production. Information will be used for long-term planning for appropriate land use. Technology used by developing country scientists and students will benefit from this and subsequent studies related to soil fertility and plant nutrition.

U.S.

The U.S. will benefit by having additional information about important Latin American soils. Specifically the information gathered will be of benefit to SMSS and IBSNAT.

Discussion:

Relation to other A.I.D. programs: This project complements other soil fertility and soil chemistry projects sponsored by SCI. It does not duplicate other activities. It is in keeping with the SCI objective to foster collaborative activities which establish linkages between U.S. scientists and students in developing countries.

Relation to state-of-the-art and the work of others: As indicated in the review of past work cited in the project proposal, there have been many studies of phosphorus retention and response of plants to various treatments. This project is innovative in two respects. Firstly, the classification of soils by their phosphorus fixing mechanism has never been tried. And the second innovative feature concerns the mechanisms to be used to overcome the P retention capacity of the soil This study also utilizes a group of bean varieties that have been previously screened for their P requirements. The results will be of considerable value to several other A.I.D. projects. It does not duplicate the work of others.

Project Profile

Project No: 3.F49

Project Title: Vicariant Fertilization for Tropical Soils

Project Duration: August 1985 - February 1986

Funding Level: $182,255

Grant Holder: University of Panama

Principal Investigator: Robustiano Alverez, University of Panama

Co-Investigators:

Donald L. Sparks, University of Delaware
Metodio Rodriquez, University of Panama
Francisco Mora, University of Panama

Cooperating Institutions:

Facultad de Agronomia" (FAUP)
University of Panama

Department of Plant Science
University of Delaware

Project Purpose:

To study the interaction between phosphates and silicates in the adsorption complex of soil sesquioxides and to further investigate the effect of Si on P availability.

Specific Objectives:

(1) To develop specifically formulated soluble silicates and phospho-silicates capable of significantly increasing P in the soil solution.

(2) To test specific fertilizers for their maximum efficiency in releasing P when incorporated in acid soils with high P fixation capacity.

(3) To select those silicated fertilizers which show the best performance and test them for their initial effectiveness in greenhouse and field experiments.

(4) To statistically evaluate the results of laboratory soil and plant tissue analysis to find the relationships between the compositions of silicated fertilizers and phosphorus availability.

Results: (scientific)

Physical, chemical and mineralogical analysis of three soils chosen as representative of Oxisols, Ultisols, and Andepts were made at the University of Delaware. The soil samples were taken and several sources of Si were analyzed at the University of Panama.

Two papers for publication in scientific journals have resulted from the investigations of the physio-chemical properties of the selected soils. The titles are, "A New View of Aluminum and Iron Coatings on Clay Particles of Tropical Soils," and, "Selected Chemical-Mineralogical Properties of Panamanian Soils." this work showed that the clay fraction of two highly weathered soils from Panama, an Ultisol and an Oxisol were coated with Al and Fe linings which drastically affect the surface properties of the cla..

Results from green house experiments using corn and highly weathered Panamanian soils that have high P fixing capacity indicate that the P available is insufficient for satisfactory growth of Corn. This condition can be overcome by fertilization with P fertilizer or by adding a Si source which enhances the availability of P. Two scientific papers have resulted from the greenhouse work.

Although field experiments were impossible during the two years approved for this project, field experiments in the third year showed that in the field, as in the greenhouse, corn plants have been shown to use natural and synthetic silicates, as vicariant fertilizers. These results correlate well with the silicate and P adsorption studies performed in the laboratory for Ultisols and Oxisols. Results were less well defined for Andepts.

Overall, four scientific papers have been presented at scientific meetings and three have been submitted for publication.

The work conducted under this project has added to the knowledge about P and Si chemistry in highly weathered tropical soils. The information has refined the knowledge about the chemistry of three important tropical soils. It has also shown that relatively inexpensive sources of Si fertilizer can substitute for some expensive P fertilizer in these soils.

Results: (linkages)

Collaboration between Scientists at the University of Panama and the University of Delaware resulting from this project will be lasting. Exposure of the Panamanian scientists to U.S. procedures and the opportunity afforded to publish in scientific journals will have a lasting positive affect on Agronomic research in Panama.

Discussion:

Relation to other A.I.D. Projects:

Reducing the amount and costs of outside inputs for food production in developing countries is a goal of A.I.D. This project contributes to that goal in that it investigates a method of enhancing the availability of native P and reduces the requirement for expensive and scarce phosphorus fertilizer. Since P deficiency for plant growth is very common in many tropical soils, and economical method for increasing the availability of P in tropical soils would be a great contribution to food production in developing countries in the tropics. It also complements projects which are in S&T/AGR.

Relation to other SCI Projects:

This project is not competitive with other SCI supported activities and addresses an important soil chemistry problem.

Relation to state-of-the-art and the work of others:

Increases in crop growth as a function of P-concentrations in the soil solution has been widely shown for tropical soils. It is known that the level of P in the soil solution required for crop growth varies with the plant species and with soils properties. It has also been shown that the amount of Si present in the soil most affects the concentration of P present in the soils solution. The beneficial effects of Si fertilization on crop growth, P availability and P uptake have been shown to be considerable in tropical soils. Several studies have shown that Si fertilization is not economically feasible. The contributions of this project to knowledge about P/Si chemistry in tropical soils relate to the physio-chemical properties of selected soils. It also showed how the application of Si releases P which is otherwise fixed in three acidic tropical soils, and how the indicator plant, used the newly available P. This study has added to the overall knowledge of P/Si chemistry of three highly acid tropical soils.

Project Profile

Project No: 7.136

Project Title: Nitrogen Dynamics of the Acacia senegal Agroforestry System in Sudan

Project Duration: June 1, 1987 - May 31, 1989

Funding Level: $129,121

Grant Holder: Old Dominion University Research Foundation

Principal Investigator: Frank P. Day, Jr., Professor of Biological Science.

Co-Investigator:
Z. Saad, Ph.D Candidate
? Graduate student in Sudan

Cooperating Institutions:

Agricultural Research Corporation, Sudan
Ministry of Agriculture

Project Purpose: To investigate the biological processes and nitrogen dynamics operative in the Acacia Senegal agroforestry system in Sudan.

Specific Objectives:

(1) To determine the ecological and genetic variability among tree populations on two main soil types in the Acacia senegal range with regard to nitrogen input to the system.

(2) To identify and locate high yielding strains of A. Senegal/rhizobial symbiont combinations.

(3) To develop a cheap method of soil improvement using biological methods.

Results: (scientific)

None to date

Research Plan: (in brief)

In persuit of the objectives of this study six (6 specific research efforts will be undertaken in the file in Sudan.

(1) Study the geographic variation of A. senegal with respect to nodulation and nitrogen yield.

(2) Identify high N yielding combinations of A. senegal and Rhizobium strains.

(3) Study the relationship between gum yield and N yield.

(4) Determine the effect of length of rotation on N yield.

(5) Study the effects of A. senegal foliage applied to the soil surface on yield of other crops.

(6) Study the rate of nutrient release from A. senegal foliage and determine the processes controlling nutrient release.

Results: (linkages)

Since this project was initiated in 1987, no significant linkages have been effected to date. However, because the research plan includes extensive field work in Sudan and includes the involvement of Graduate Students for Sudan and the Agricultural Research Corporation of Sudan, it is evident that linkages will be established which should be lasting.

Results: (Improved scientific capacity)

Developing country:

Experiences gained by scientists and students in Sudan will strengthen their scientific capacity by the time this project is completed.

U.S.:

Experiences gained in a developing country will enrich the backgrounds of the U.S. persons involved.

Discussion:

Relation to other A.I.D. projects:

This project is complementary to other A.I.D. projects in the area of BNF. It is compatible with other projects aimed at utilizing marginal areas. It also supports A.I.D.'s efforts to help developing countries improve their foreign exchange situation by producing export crops.

Relation to SCI projects:

this project is complementary to other SCI projects aimed at improving BNF and at utilizing marginal resources.

Relation to state-of-the-art and work of others:

The project plan is sound and utilizes proven methods. State-of-the-art techniques will be used, however, this project will not contribute significant new methodology. It will contribute new knowledge about the management of A. senegal and provide new and useful information about its use in marginal areas in Sudan and elsewhere.

DISTRIBUTION:

Dr. Anson Bertrand, 1547 Montpelier Street, Petersburg, VA 23805
(804) 732-1638 (2)

SAA/S&T, Dr. Nyle C. Brady, 4942 NS (2)

S&T/AGR, Dr. David Bathrick, 409 SA-18 (1)

S&T/AGR, Dr. Lloyd Frederick, 420A SA-18 (1)

SCI Circulation

SCI, Dr. John Daly (chron file) (1)

Project files, project officers and principal investigators of:
2.A-22
3.A-02
3.F-10
3.F-49
5.249
C5-001
C5-325
7.136

PPC/CDIE, 209 SA-18 (2)

SCI:ABertrand:3305A